SPECIFICATION

[Title of the Invention]

OPTICAL RECORDING MEDIUM ON WHICH MULTI-MODULATED HEADER SIGNALS ARE RECORDED, METHOD AND APPARATUS FOR RECORDING HEAER SIGNALS AND METHOD AND APPARATUS FOR REPRODUCING HEADER SIGNALS

[Brief Description of the Drawings]

FIG. 1 is a schematic diagram of a conventional optical disk;

FIG. 2 is a schematic diagram of an optical disk according to a preferred embodiment of the present invention;

FIG. 3 is a reference diagram showing the wobbled track and the header area of FIG. 2;

FIG. 4 is a block diagram of an apparatus for recording a header signal according to the present invention;

FIGS. 5A and 5B are implementation examples of the apparatus of FIG. 4;

FIG. 6 is a reference diagram for explaining a header signal generated by the multi-modulator of the apparatus of FIG. 4;

FIG. 7 is a reference diagram for explaining a wobbled track and a header area according to the present invention;

FIG. 8 is an example of the format of a wobbled track and a header area according to the present invention;

FIG. 9 is a block diagram of a header information reproducing apparatus according to the present invention; and

FIG. 10 is an implementation example of the apparatus of FIG. 9.

[Detailed Description of the Invention]

[Object of the Invention]

[Technical Field of the Invention and Related Art prior to the Invention]

The present invention relates to optical recording and reproducing, and more particularly, to a wobbled track on which user data is recorded, an optical recording medium including a header area on which a header signal having header information is recorded, a method and apparatus for recording the header signal, and a method and apparatus for reproducing the header signal.

An optical recording medium has a header area on which header information is recorded and a user data area on which user data is recorded. In 2.6 GB or 4.7 GB DVD-RAM, 128 bytes of header information is recorded in the form of pre-pits in manufacturing a disk substrate. According to the DVD-RAM specification, the header area on which pre-pits are formed in manufacturing a disk substrate includes a variable frequency oscillator (VFO) region for phase-locked loop (PLL), a physical identification data (PID) region for recording addressing information, an ID error detection (IED) region for storing ID error detection information, and a post amble (PA) region. The header area is provided at a predefined position on a sector, and a pick-up in a recording/reproducing apparatus locates a desired location through addressing information recorded in the header area. That is, the pick-up recognizes information such as a sector number, a sector type, land/groove track, and servocontrol information recorded in the header area.

As the use of multimedia quickly has grown in popularity and with the advent of digital broadcasting, it is highly desirable to have an optical recording medium which can store much more data.

FIG. 1 is a schematic diagram of a conventional optical disk. Referring to FIG. 1, an optical disk includes land and groove tracks, which are a user data area for recording user data. Variations in an amplitude direction are used to record a wobble signal having a specific frequency on the groove and/or land tracks. The wobble signal is used as an auxiliary clock signal for obtaining synchronization information while recording and reproducing data. Hence, the wobble signal has a frequency band that has no impact upon a tracking servo-mechanism provided in a recording/reproducing

apparatus. Header information is recorded on a header area 3 in the form of pre-pits. The pre-pits are arranged in a staggered fashion so that they are between adjacent sectors.

Since the header information is recorded by pre-pits unlike the wobble signal, a signal detected from the header area 3 has quite different characteristics from those of the wobble signal. Thus, the header area 3 may causes disturbance in extracting a clock signal from the wobble signal. Furthermore, it is difficult to exactly detect a boundary between the wobbled track on which the wobble signal is recorded and the header area 3, thereby degrading reliability of detected header information.

[Technical Goal of the Invention]

To solve the above problems, it is an object of the present invention to provide an optical recording medium on which a header signal capable of making more reliable header information to be detected is recorded, a method and apparatus for recording the header signal, and a method and apparatus for reproducing the header signal.

It is another object of the present invention to provide an optical recording medium on which a header signal having a greater amount of header information is recorded, a method and apparatus for recording the header signal, and a method and apparatus for reproducing the header signal.

Accordingly, to achieve the above objects, the present invention provides an optical recording medium including: a wobbled track on which user data is recorded; and a header area on which a header signal having multi-modulated header information is recorded.

Preferably, first and second header information modulated according to first and second types of modulation, respectively, overlap each other in at least some of intervals of the header signal. The first type of modulation is one of phase modulation, frequency modulation, and amplitude modulation, and the second type of modulation is one of the remaining two types of modulation.

Preferably, first through third header information modulated according to first through third types of modulation overlap one another in at least some of intervals of the header signal. The first type of modulation is one of phase modulation, frequency modulation, and amplitude modulation, the second type of modulation is one of the remaining two types of modulation, and the third type of modulation is the last one. More preferably, first through N-th header information modulated according to first through N-th types of modulation, respectively, overlap one another in at least some of intervals of the header signal. Here, the first through N-th types of modulation are different from one another.

The header area may further include a header flag region on which a flag signal indicative of the beginning of the header area positioned between adjacent wobbled tracks is recorded. A direct current signal may be recorded on the header flag region or the header flag region may be formed as a mirror region.

The wobble signal has a single frequency, and the heater signal has a frequency higher than that of the wobble signal.

The present invention also provides a method for recording header information on the header area on an optical recording medium on which a wobble signal is recorded. The method includes the steps of: (a) generating a header signal having multi-modulated header information; and (b) recording the generated header signal.

In the step (a), a header signal including at least some of intervals where first and second header information modulated according to first and second types of modulation, respectively, overlap each other is generated. Preferably, the first type of modulation is one of phase modulation, frequency modulation, and amplitude modulation, and the second type of modulation is one of the remaining two types of modulation.

Alternatively, in the step (a), a header signal including at least some of intervals where first through third header information modulated according to first through third types of modulation, respectively, overlap one another is generated. Preferably, the step (a) includes the steps of: (a1) modulating the first header information according to a first type of modulation; (a2) modulating the second header information according to a

second type of modulation; (a3) modulating the third header information according to a third type of modulation; and (a4) overlapping the signals obtained in the steps (a1)-(a3). Preferably, the first type of modulation is one of phase modulation, frequency modulation, and amplitude modulation, the second type of modulation is one of the remaining two types of modulation, and the third type of modulation is the last one.

The present invention also provides an apparatus for recording a header signal on a header area on an optical recording medium on which a wobble signal is recorded. The apparatus includes: a multi-modulator that multi-modulates header information and generates a header signal; and a recording portion for recording the generated header signal.

Preferably, the multi-modulator includes a first modulator for modulating the first header information according to a first type of modulation, a second modulator for modulating the second header information according to a second type of modulation, and a signal synthesizer for overlapping the signals output from the first and second modulators in at least some of intervals. The first type of modulation is one of phase modulation, frequency modulation, and amplitude modulation, and the second type of modulation is one of the remaining two types of modulation.

More preferably, the multi-modulator may include a first modulator for modulating first header information according to a first type of modulation, a second modulator for modulating second header information according to a second type of modulation; a third modulator for modulating third header information according to a third type of modulation; and a signal synthesizer for overlapping the signals output from the first through third modulators in at least some of intervals. The first modulator performs one of phase modulation, frequency modulation, and amplitude modulation, the second modulator performs one of the remaining two types of modulation, and the third modulator performs the last one.

The present invention also provides a method for reproducing header information from a header area on an optical recording medium on which a wobble signal is recorded. The method includes the steps of: (a) reading a header signal

having multi-modulated header information; (b) demodulating at least some of intervals of the read header signal according to a first type of demodulation to obtain first header information; (c) demodulating the intervals of the read header signal according to a second type of demodulation to obtain second header information; and (d) combining the first and second header information obtained in the steps (b) and (c), respectively, to output the combined header information.

In another embodiment, the method may include the steps of: (a) reading a header signal having multi-modulated header information; (b) demodulating some of intervals of the read header signal according to a first type of demodulation to obtain first header information; (c) demodulating the intervals according to a second type of demodulation to obtain second header information; (d) demodulating the intervals according to a third type of demodulation to obtain third header information; and (e) combining the first through third header information obtained in the steps (b)-(d) to output the combined header information.

[Structure and Operation of the Invention]

The present invention also provides an apparatus for reproducing header information from a header area on an optical recording medium on which a wobble signal is recorded. The apparatus includes: a reading portion that reads a header signal having multi-modulated header information; a first demodulator that demodulates at least some of intervals of the read header signal according to a first type of demodulation and obtains first header information; a second demodulator that demodulates the intervals according to a second type of demodulation and obtains second header information; and a header information synthesizer that combines the first and second header information and outputs the combined header information.

Preferred embodiments of the present invention will now be described with reference to the attached drawings.

Referring to FIG. 2, spiral wobbled tracks for recording user data are formed on an optical disk. The wobbled tracks include groove tracks and land tracks. Also, the wobbled tracks may be concentric circles. A wobble signal of a specific frequency is recorded on the wobbled track. A plurality of header areas 2 on which header information is recorded are positioned between adjacent wobbled tracks. In this way, the wobbled track and the header area 2 are positioned alternately.

Referring to FIG. 3, a single wobble signal having a single frequency is recorded on the groove and land tracks. A recording layer for overwriting or recording data only once is applied on the groove and land tracks. If user data is recorded, a mark is formed on the recording layer. Tracks are continuously formed on the header area 2 so that they correspond to the groove and land tracks of the user data area. A header signal having header information is recorded on the tracks formed on the header area 2. The header information contains addressing information. Since the header signal contains various kinds of header information, it has a frequency higher than that of the wobble signal recorded on the wobbled tracks. The header signal will be described below in detail.

The tracks are formed on the header area 2 like in the user data area. Thus, the geometry of the optical recording medium according to the present invention is more uniform than that of a conventional optical recording medium including a header area on which pre-pits are recorded. The amount of a laser beam reflected becomes more uniform in recording data on an optical disk having a dual-layered structure as well as on that having a single-layered structure. Thus, header information can be reproduced with power less than that required for reproducing header information recorded by pre-pits.

FIG. 4 is a block diagram of an apparatus for recording a header signal according to the present invention. Referring to FIG. 4, the header signal recording apparatus includes a multi-modulator 41 and a recording portion 42. The multi-modulator 41 receives header information to generate a header signal having multi-modulated header

information. The recording portion 42 records the header signal generated by the multi-modulator 41 on an optical disk 400.

FIGS. 5A and 5B are implementation examples of FIG. 4. Referring to FIG. 5A, the multi-modulator 41 includes a first modulator 51, a second modulator 52, and a signal synthesizer 53. The first modulator 51 modulates fist header information according to a first type of modulation. The second modulator 52 modulates second header information according to a second type of modulation. The first modulator 51 performs one of phase modulation, frequency modulation, and amplitude modulation, while the second modulator 52 performs one of the two remaining ones. The first and second modulators 51 and 52 may perform modulation other than the above three modulation techniques depending on the type of application. The signal synthesizer 53 overlaps the signals output from the first and second modulators 51 and 52 in at least some of intervals to generate a header signal. Here, the first and second header information makes up the header information. The first and second header information may be different from each other or at least some of them may be identical.

Referring to FIG. 5B, the multi-modulator 41 includes a first modulator 54, a second modulator 55, a third modulator 56, and a signal synthesizer 57. The first modulator 54 modulates fist header information according to a first type of modulation. The second modulator 55 modulates second header information according to a second type of modulation. The third modulator 56 modulates third header information according to a third type of modulation. The first modulator 54 performs one of phase modulation, frequency modulation, and amplitude modulation, the second modulator 55 performs one of the two remaining ones, and the third modulator 56 performs the last one. The first through third modulators 54, 55, and 56 may perform modulation other than the above three modulation techniques depending on the type of application. The signal synthesizer 57 overlaps the signals output from the first through third modulators 54, 55, and 56 in at least some of intervals to generate a header signal. Here, the first through third header information makes up the entire header information. The first

through third header information may be different from one another or at least some of them may be identical.

FIG. 6 is a reference diagram for explaining a header signal generated by the multi-modulator 41 of the header signal recording apparatus according to the present invention. Referring to FIG. 6, if header information contains binary data "010101000011011101010100" and it is divided into three parts to have first, second, third header information, the first header information is frequency-modulated, the second header information is phase-modulated, and the third header information is amplitude-modulated. The frequency of a carrier signal used in the frequency modulation, phase modulation, or amplitude modulation is determined as a multiple of the frequency of a single frequency wobble signal, thereby making extraction of an auxiliary clock signal in the header area 2 efficient. (a) of FIG. 6 is a schematic diagram of a header signal having the first through third header information modulated according to the above types of modulation. Here, A denotes a header flag region. The header flag region A serves as a flag indicative of the beginning or end of the header area 2. To this end, a dc signal is recorded on the header flag region A, or the header flag region A is formed as a mirror region in which no signal is recorded. If the dc signal is recorded, the amplitude of a channel 2 signal detected from the header flag region A is zero. If a laser diode partitioned into four sections A, B, C, and D is used for detecting signals, channel 2 and channel 1 signals mean (A+B)-(C+D) and (A+B)+(C+D), respectively. The wobble signal and the header signal are detected as the channel 2 signal.

(b) of FIG. 6 is a header signal obtained as a result of simulation using a wavelength of 400 nm, a numerical aperture (NA) of 0.85, 32 a wobble signal period of 32 channel bits, wobble signal amplitude of ±10nm, and track pitch of 0.32 μm. In this way, the header signal according to the present invention has the duplicate or triplicate header information at the same region, thereby allowing for a double or triple recording density.

FIG. 7 is a reference diagram of a wobbled track and a header area according to the present invention. Referring to FIG. 7, (a) is a channel 2 signal detected from the wobbled track and the header area formed according to the present invention, and (b) and (c) show a header area on which a header signal is recorded and a wobbled track on which a single frequency wobble signal is recorded according to the present invention. The header area of (b) has a header flag region on which a dc signal is recorded, while the header area of (c) has a header flag region formed as a mirror region. The amplitude of the channel 2 signals detected from the header flag region on which a dc signal is recorded and that formed as a mirror region is zero. (d) of FIG. 7 is a write power Pw used in writing user data to the wobbled track. As shown in (d), the user data is recorded with the write power Pw, while a header signal is detected with a reproduce power Pr that is lower than the write power Pw. The reproduce power Pr is sufficiently high to detect the header signal recorded on the header signal. Also, use of the reproduce power Pr, which is lower than the write power Pw, may prevent or delay degradation of the header signal compared to the use of the write power Pw.

FIG. 8 is an example of the format of the wobbled track and the header area according to the present invention. Referring to FIG. 8. if a recording block has 32 sectors or 64KB when 2KB is assigned per sector, 64KB of recording block corresponds to 274 bytes of header area. The first 2 bytes are allocated for a header flag region, and the remaining 272 bytes are divided to allocate 52 bits for each of first through fourth header information ID0, ID1, ID2, and ID3. Each of the first through fourth header information ID0, ID1, ID2, and ID3 is recorded four times. Each of the header information ID0, ID1, ID2, and ID3 has 5 bits (b0–b4) of sync data, 31 bits (b5-b35) of block number (addressing information), and 16 bits (b36-b51) of ID error detection (IED) data. In this case, one bit is represented by four periods of a header signal, and the period WT of the header signal corresponds to 16 channel clocks. Since 1 error correction code (ECC) block has 16 sectors in the conventional DVD-RAM specifications, each recording block consists of two ECC blocks if data is allocated as shown in FIG. 8.

FIG. 9 is a block diagram of a header information reproducing apparatus according to the present invention. Referring to FIG. 9, the apparatus for reproducing header information from a header area on an optical recording medium on which a wobble signal is recorded is configured to include a reading portion 91, a multi-demodulator 92, and a header information synthesizer 93. The reading portion 91 reads a header signal having multi-modulated header information from an optical disk 900. The multi-demodulator 92 multi-demodulates the read header signal to get header information. The header information synthesizer 93 combines the header information with each other to output the result as final header information.

FIG. 10 is an example of the apparatus of FIG. 9. Referring to FIG. 10, the multi-demodulator 92 includes first through third demodulators 101, 102, and 103. The first demodulator 101 demodulates a read header signal according to a first type of demodulation to obtain first header information. The second demodulator 102 demodulates the read header signal according to a second type of demodulation to obtain second header information. The third demodulator 103 demodulates it according to a third type of demodulation to obtain third header information. The header information synthesizer 93 combines the first through third header information to output header information. Here, the type of demodulation is determined depending on the type of modulation adopted in generating a header signal. For example, if frequency modulation, phase modulation, and amplitude modulation are sequentially used to generate a header signal, the first through third demodulators 101, 102, and 103 demodulate the read header signal based on the frequency, phase, and differential phase of the read header signal, respectively, to get the first through third header information of binary data. The header information synthesizer 93 combines the first through third header information to obtain final header information. For example, if the first through third header information is represented by "01010110", "00101100", and "00101100", respectively, the header information synthesizer 93 arranges and combines them successively to obtain the final header information represented by "010101000011011100101100".

To investigate recording/reproducing characteristics for a header area on which a header signal according to the present invention is recorded, an optical recording medium having only user data area is compared with that having a header area, on which the header signal according to the present invention is recorded, as well as a user data area, in terms of a minimum mark length (MML). As a MML decreases, the recording density of an optical recording medium increases. However, if the MML is too small, it is impossible to manufacture an optical recording medium. This is because there is a limit in reducing the intensity of a laser beam for recording. The results in Tables 1 and 2 demonstrate that header information has a feasible MML even if a header signal according to the present invention is used to record header information having triple recording density.

To accomplish this, assuming that a 52-bit header information unit has 4bits of sync data, 32 bits of addressing information (physical identification data (PID) information), and 16 bits of IED data, and that one sector corresponds to 38,688 channel bits, the period of a header signal is determined as shown in Table 1. Here, a channel bit refers to an actually recorded clock bit, which means a clock bit for recording binary data obtained as a result of 8/16 modulation used in a conventional DVD.

Table 1

Number of repetitions		1 repetition			2 repetitions			3 repetitions			
Nr of periods/1bit		TPID= 1	TPID= 4	TPID= 8	TPID= 1	TPID= 4	TPID= 8	TPID= 1	TPID= 4	TPID= 8	TPID= 36
Sector		744	186	93	372	93	46	186	46	23	
ECC block	1 ECC block (32KB)	11904	2976	1488	5952	1488	736	2976	736	368	
	2 ECC block (64KB)	–	–	–	–	–	1488	–	1472	736	163

Here, TPID denotes the number of periods of a header signal required for

representing 1 bit. As is evident from Table 1, as TPID increases, an error rate decreases, but the period becomes shorter. The data capacity required for a header area according to the present invention and the period of a header signal are calculated based on the computed values of Table 1 as shown in Table 2.

Table 2

TPID	Period of header signal (channel bit)	FM + PM + AM		
		Capacity (bytes)	Overhead	MML (μm)
1	32	137	0.21%	
	16	69	0.11%	
2	32	274	0.42%	
	16	137	0.21%	
4	32	541	0.84%	0.184
	16	274	0.42%	0.185
8	32	1082	1.68%	0.182
	16	548	0.84%	
		0	0	0.186

Table2 shows the result of simulation of a MML obtained assuming that 64 KB is allocated per header area, and that a header information unit is recorded four times on the header area having a track pitch of 0.32 μm using groove recording while the user data region has a track pitch of 24-58 mm and 25 GB of recording capacity. That is, when a frequency-modulated signal, a phase-modulated signal, and an amplitude-modulated signal overlap one another according to the present invention to generate a header signal having three times the recording density of a single modulated signal, if the header signal has a period of 32 channel bits, an overhead and a MML for each recording block are 0.84% and 0.184 μm, respectively. If the header signal has a period of 16 channel bits, an overhead is 0.42% and a MML is 0.185 μm. The MML is 0.001 μm shorter than a MML of 0.186 μm obtained on the assumption that only user data area exists. In view of the simulation result, it is possible to implement MML through a current laser recording technique even if the header signal according to the present invention is used to record

header information with double or triple recording density. That is, a header area on which a header signal according to the present invention is recorded has no problem in recording or reproducing data.

Although the present invention has been described with respect to generation of a double or triple modulated header signal by the multi-modulator 41, it is possible to generate a header signal modulated according to N types of modulation. If the N types of modulation are performed on a header signal, the multi-modulator 41 includes first through N-th modulators for performing different types of modulation and a signal synthesizer for combining signals output from the N modulators, which overlap one another in at least some of intervals. Thus, the multi-demodulator 92 of the header information reproducing apparatus includes first through N-th demodulators for performing different types of demodulation corresponding to the first through N-th modulators. The header information synthesizer 93 of the reproducing apparatus combines the header information output from the first through N-th demodulators.

[Effect of the Invention]

As described above, according to the present invention, header information is recorded by a header signal in place of pre-pits, thereby detecting channel 2 signal more stably and reproducing more reliable header information. Furthermore, the present invention enables a header signal to have a greater amount of header information, thereby reducing the area of a header area while providing a wider user data area.